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The limit of probable detection in the weight of the lamp would have been ± 1 mgm., while a change of ± 3 mgms. would hardly have escaped observation, a percentage of 0.35, or nearly one part in 300.

It would, of course, be quite possible to reduce considerably this outstanding limit of uncertainty, by making the necessary weight in the lamp wire, and with increased care in mounting the same.

Appendix. The electro-magnetic repulsion acting in these experiments can be approximately computed from a formula due to CLERK-MAXWELL.

$$f = 2c^2 \log_e \left(\frac{d}{r} \right)$$

where f is the force of repulsion in dynes, c is the current flowing through the circuit in absolute measure, d is the distance separating the axes of the wires, in cms., and r is the radius of the wires in cms.

In this case c is 2.9 amperes, or 0.29 units, d is 0.5 and r is 0.0033. Whence f is 0.84 dyne, equivalent to 0.86 milligramme weight, or of the same order as the first effect noticed.

EDISON LABORATORY, ORANGE, N. J., 29th Oct., 1890.

CORONAL EXTENSION.

BY C. M. CHARROPPIN, S. J.*

The most distant stretch of the streamers of future eclipses, in all probability, will never be recorded on a sensitive plate; because, since the coronal rays diminish in brightness as they recede from the sun, a limit must be reached, when the faintest beams will be of equal brightness with the illuminated air: then, and only then, will they fail to impress themselves on the photographic plate: for the haloid salts of silver deal only with lights and shadows. They will delineate the most delicate pencils of light: they will record the very line where the faintest ray is immersed in the tiniest shadow: but when contrast ceases to exist, they at once become dumb. The faintest beam of nebulous matter, which the large eye of the most powerful telescope refuses to reveal, leaves its impression on the sensitive plate: but the same silvered film will often fail to notice the brightest of Jupiter's satellites in transit, when projected on the planet's disc. Why, then, should the almost beamless nebula be

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photographed, and a bright satellite leave no impression? Because, in the first instance, there was contrast between the faintest pencil of light and a dark background; in the second place, this contrast was wanting; the two discs reflecting nearly the same amount of light.

Thus far I have advanced no new theory. I have stated a fact which Prof. HOLDEN has alluded to in his article on the eclipse of December 21st, a fact well understood by the scientific fraternity at large.* If I have insisted upon this point, it is because I consider it the key to the solution of the problem of photographing the extension of the outer corona.

Much has been said and written concerning the instrument best adapted to the photographing of the corona—whether the reflector will give better results than the refractor—whether large objectives are preferable to smaller ones, etc. Again, the question of diaphragms has been much discussed; and, as to the limit of proper exposures, the conflicting opinions are, "*Sine fine dicentes*." But how little has been said about the proper development of the photographic plate after exposure, and yet success depends principally upon this trying operation!

It is one thing to make a proper exposure, and another to secure, in the development of the latent image, its most delicate details. It requires judgment and a practised eye to know when to retard and when to accelerate the developer. If the negative is under-developed, the niceties of the faintest shadows are not brought out. Let the negative be over-developed, then those minute details and slightest contrasts are all lost in one common blur. Do you desire to bring out a cloud effect in a landscape, then your exposure must be very short; nay, instantaneous; but you are apt to lose the finest details of the woodland scene. If, on the contrary, you are endeavoring to bring out the softest contrast of the tinted leaves of that autumnal forest, your exposure will be longer, your developer will be retarded by Potassium bromide, but, meanwhile, your clouds will be lost in a perfectly black sky. There lies precisely the difficulty of photographing a total eclipse of the sun. You aim at capturing the full extent of coronal streamers, and, at the same time, you expect the polar filaments to be well defined on your cliché. In the one field a perfect negative is to be obtained of four different light-giving objects, differently illuminated, requiring four different exposures, viz: the actinic protuberances; the bright inner corona; the polar filaments; and the extremely delicate shadings of the extended

* See Publ. A. S. P. vol. II, pages 94 *et seq.*

streamers. To attack the problem with any hope of perfect success, especially when the full extent of the outer corona is desired, I would propose the plan of Horatius encountering the three Curiatii,—separate the enemy. If the maximum extension of coronal streamers be desired, the outer corona must be photographed independently. The inner corona should be just on the margin of the field. Its position, though out of sight, should be well defined ; otherwise all future measurements would become impossible. The exposure for a Seed's 26 may range between 30 and 50 seconds, whereas the full eclipse could be captured in 3 to 5 seconds. With skillful manipulation, I have no doubt that a negative can be obtained giving greater extension to the streamers than photography has yet been able to accomplish.

Now we may turn to the question of exposure. No doubt we should always aim at a correct exposure. In developing a well-timed plate we may expect a minimum of difficulties : but how seldom in out-door photography will an exact exposure be obtained ! In photographing a bright object, the difference of a second of time may either under or over-expose a plate. In the hands of a skillful operator this accidental time will be counteracted by proper manipulation.

Many factors enter into the calculation of a correct exposure, viz : the altitude of the sun, the condition of the atmosphere, the light-ratio of the lens, the size of the stop, the focal length of the objective, the proper illumination of the object to be photographed, etc. Atmospheric disturbances are, perhaps, the most important factors to deal with in celestial photography. When the altitude of the sun is small and the atmosphere is disturbed, it is impossible to obtain a great extension of coronal rays. But let us suppose that all the conditions are most favorable ; that the objective is well corrected for spherical aberration and chemical rays ; totality happens in summer ; the sun is near culmination in an Italian sky ; still there remain serious difficulties which will always make a total eclipse the most difficult picture to be taken in the whole range of photography.

I am inclined to favor long exposures whenever very faint details in the shadows are to be photographed. A long exposure does not necessarily imply an over-exposure ; but often leads to it. I should not fear an over-exposure so long as I could prevent a fog. I believe that more delicate details may be obtained from over-exposure than otherwise. The negative may be flat, wanting in density, but this

defect may be corrected later on by intensifying the negative. Over-exposure, however, has its limits. It does not follow, by any means, that if an exposure of one minute, to coronal rays, gives a fair amount of extension to the streamers, that doubling the time a greater extension will be obtained. No, you have crossed the limit of over-exposure, and a fogged plate is the inevitable consequence.

One of the negatives of Prof. PRITCHETT'S party, taken at Norman, Cal., January, 1889, received an exposure of 30 seconds. Although the polar filaments are almost blurred from over-exposure, and the Eastern motion of the moon has left its trace on the inner corona, still this cliché gives the greatest extension to the outer corona. This, however, must be noticed, that bright objects, such as a cloud near the sun, will hardly admit of over-exposure on account of the intense diffused light in the field. Very sensitive plates, such as a Seed's 26 are unfit for such work; I should rather use a Seed's 23, with a very small stop and a quick shutter; or, still better, a Vogel's Orthochromatic plate.

Another point of vital importance to be attended to, is the necessity of shielding the sensitive plate from all foreign light. A Seed's 26 will be affected by any light whatsoever; even by the so-called non-actinic red light of the dark room. This may not be noticed on the high lights of the picture, but the soft and delicate shades in the deep shadows will most certainly suffer, if the negative be exposed uselessly to the non-actinic light of the dark room. I would recommend to insert the plates into their carriers and to begin the process of development in total darkness.

Allow me to cite an example which I think is to the point. Of all the different parties, which took part in the California eclipse of 1889, Prof. PICKERING'S station at Willows was certainly the best equipped. The long experience and skill of this able Astronomer, raised the expectation of all, and naturally invited us to look for the best results from that quarter, but a fatal oversight prevented the expected results. Instead of having a shutter attached to his 13-inch telescope, a plain board was placed 9 inches from the objective, in order to mask the sensitive plate between the different exposures. The diffused coronal light which entered the instrument sideways and affected the plates as soon as the slide was removed, was sufficient to give a slight fog to his negatives, and thus marred the beauty of his best eclipse pictures.

Another consideration which may have escaped the notice of experimenters, is that the exposure is greatly modified by the developer.

The same exposure may give all the result of an under-timed picture with one developer, and of an over-timed negative with another. An experiment of last winter will make my meaning clear. With a six-inch objective, 92-inch focus, I made four exposures on the crescent moon. All the plates used were Seed's 26; time one-fourth of a second. In developing plate no. I, I used a cold pyrogalllic solution. Result—an under-timed plate; no details. The second plate was developed with a normal solution of Hydroquinone. Result,—more details, but still under-timed. Plate no. III, was brought out by Eikonogen. Result,—perfect details, appearance of a well-timed negative. For Plate no. IV, I used the same Pyrogalllic developer used on Plate no. I, only it was heated to 130 degrees. Result, an over-exposed negative which had to be retarded with K Br. This proved to be the best negative, on account of the richness of its details. I should add, however, that all brands of plates will not stand this high temperature. In winter, Seed's and Cramer's plates will give beautiful results, with this warm treatment, especially for instantaneous work. The gelatine film becomes very soft, hence great care is required in all subsequent washings.

By way of recapitulation, I may recommend the following, in order to obtain greater extension of coronal streamers.

I—To use Orthochromatic plates. I consider Vogel's Eoside of silver the best, when fresh, or Seed's 26, when developed with a warm pyro developer in winter.

II—The greatest precaution to guard from all foreign light.

III—Short exposures to obtain the polar filaments and the inner corona.

IV—Long exposures to secure the extension of the outer corona.

V—Photographing each wing separately, and keeping the brighter part of the eclipse out of the field.

ST. CHARLES, MISSOURI, October, 1890.

THE KENWOOD PHYSICAL OBSERVATORY.

BY GEORGE E. HALE.

At the request of Prof. HOLDEN, I am glad to write the following account of our new observatory in Chicago. The special nature of the work for which it is designed may give this paper an interest it would not otherwise possess.